International R&E Networking for US LHC Centers

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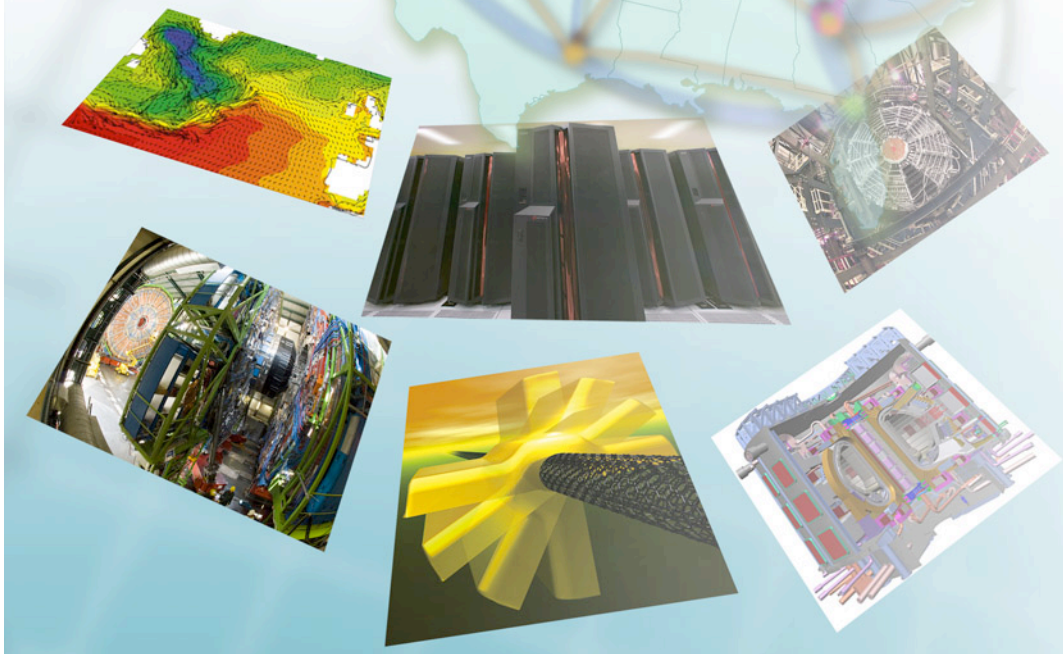
US LHC Networking Meeting @ BNL



Networking for the Future of Science

Disclaimers

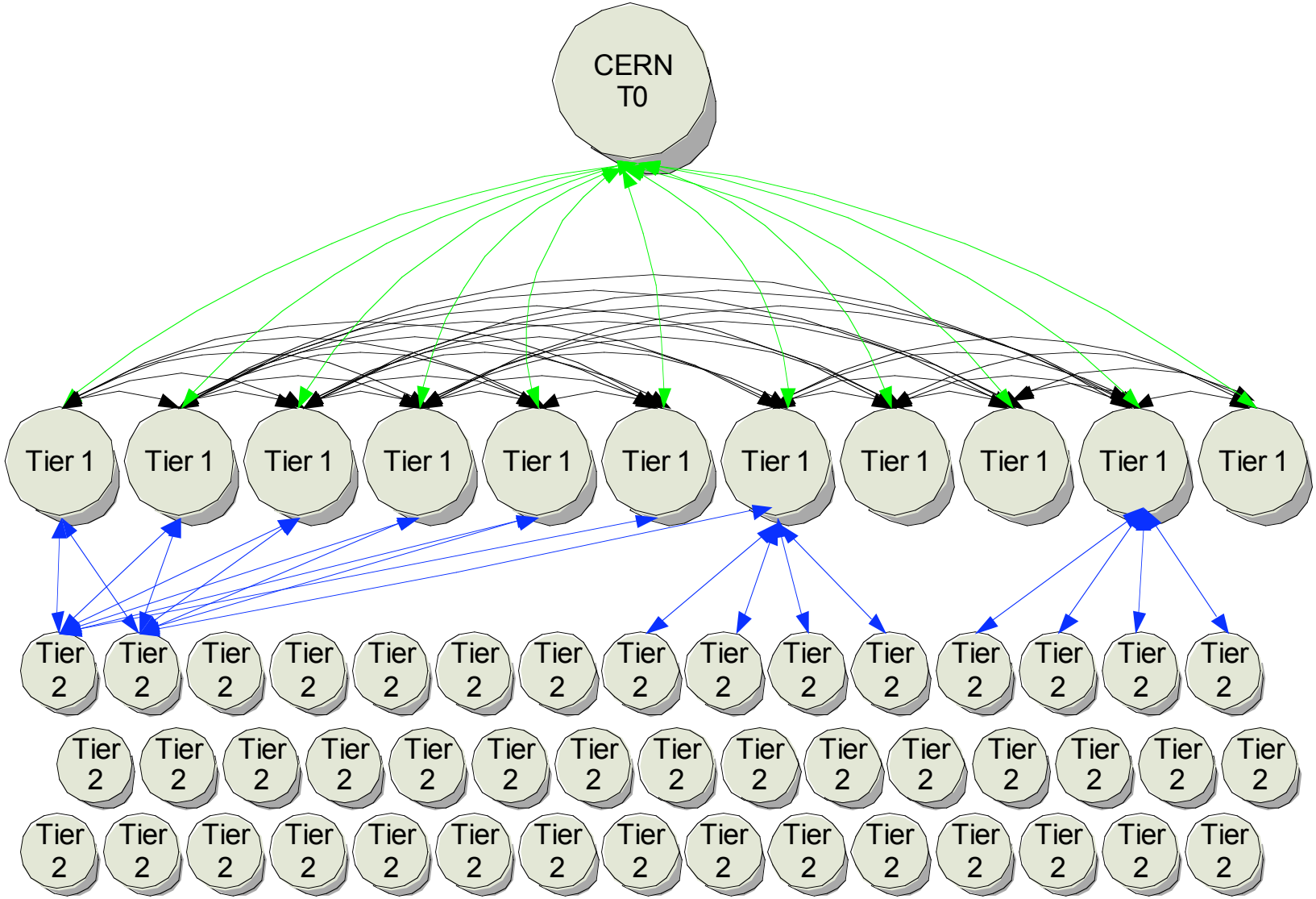
- ESnets mission includes supporting the networking requirements of the US LHC Tier 1 centers.
- It does not include directly supporting the networking needs of the universities running the US LHC Tier 2 & 3 centers.

- I would like to thank Brent Sweeney, Heather Boyles, Joe Mambretti, Dan Nae and the rest of the community for drawings that I copied and put in this presentation.

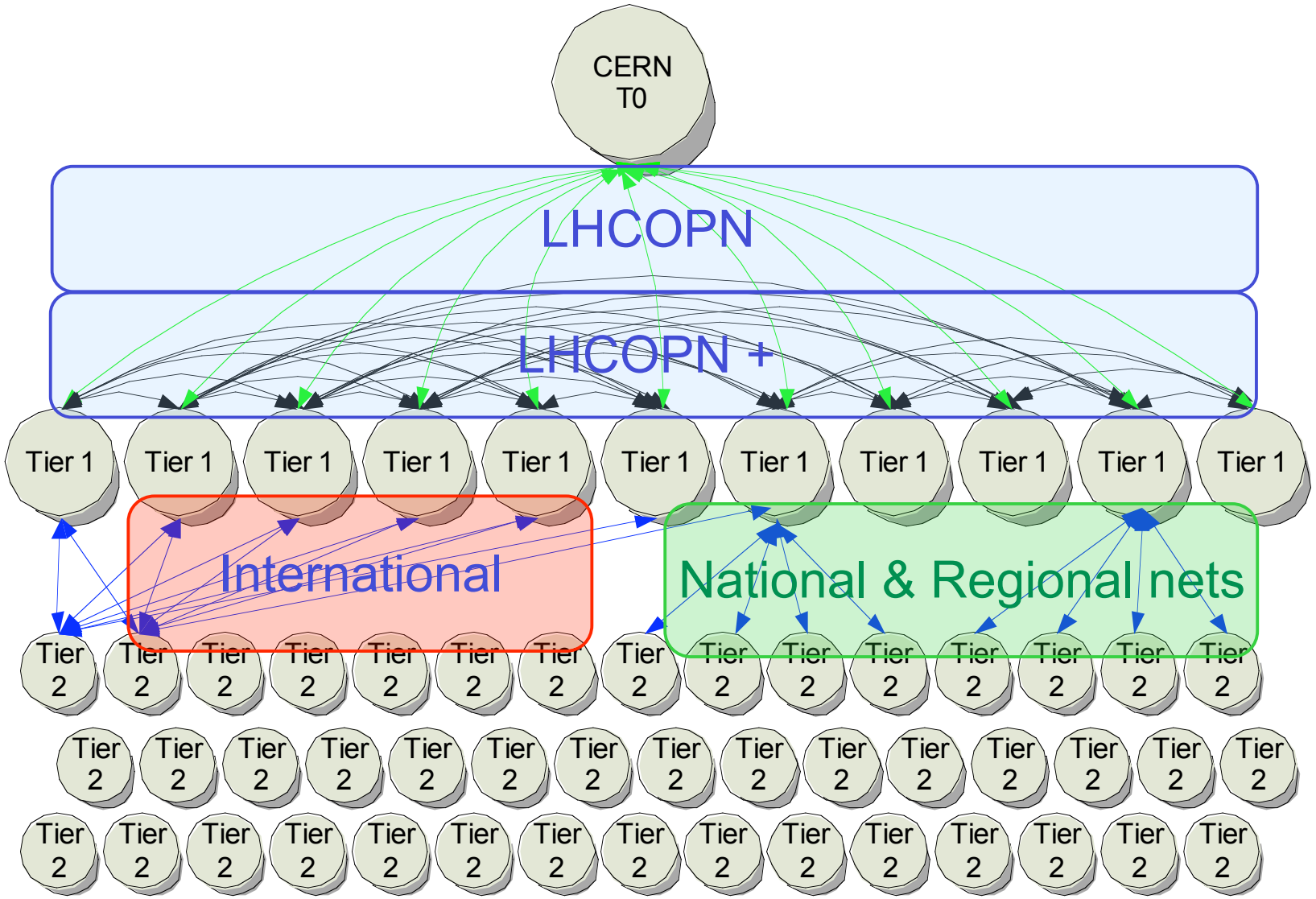
Data Model Implications for International Net Reqs

- My understanding of the current data model is:
- Atlas
  - Uses a geographical hierarchal model
  - US Tier 2 & 3 centers will obtain data from BNL.
  - So, there is no significant international networking requirements except for BNL?
- CMS
  - Ignores geography
  - US Tier 2 & 3 centers will obtain data from any Tier 1 center that has the data, which may be outside the US approximately 50%-70%(?) of the time.
  - International Tier 2's may need to get 50% of their data from FNAL

Data Distribution Models



Data Distribution Models



Players

- Large Continent sized R&E Networks
  - Internet2, NLR, ESnet, GEANT2, GLORAD,
- Regional or National R&E Networks
  - European NRENS
  - Gigapops & Regionals in US
- Mission specific networks
  - USLHCnet
  - LHCOPN
- Global scale exchange points
  - Starlight, 32 Avenue of Americas, Netherlight, Pacwave, Awave
- Typical Paths

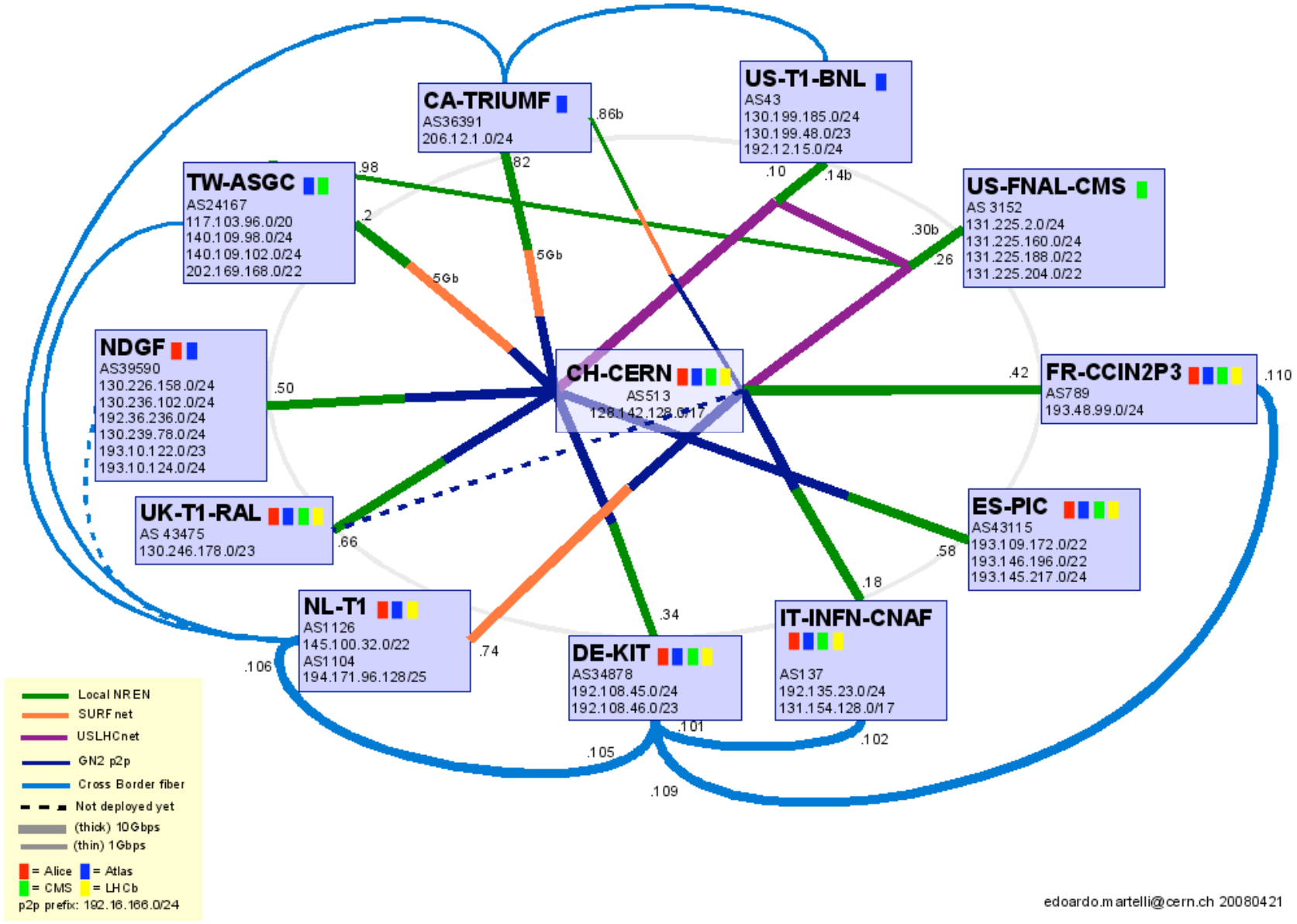
Europe T1 -> NREN -> GEANT2 ->* (NLR or Internet2) -> Regional/Gigapop -> US University

Europe T1 -> NREN -> GEANT2 ->* ESnet -> US DOE Lab

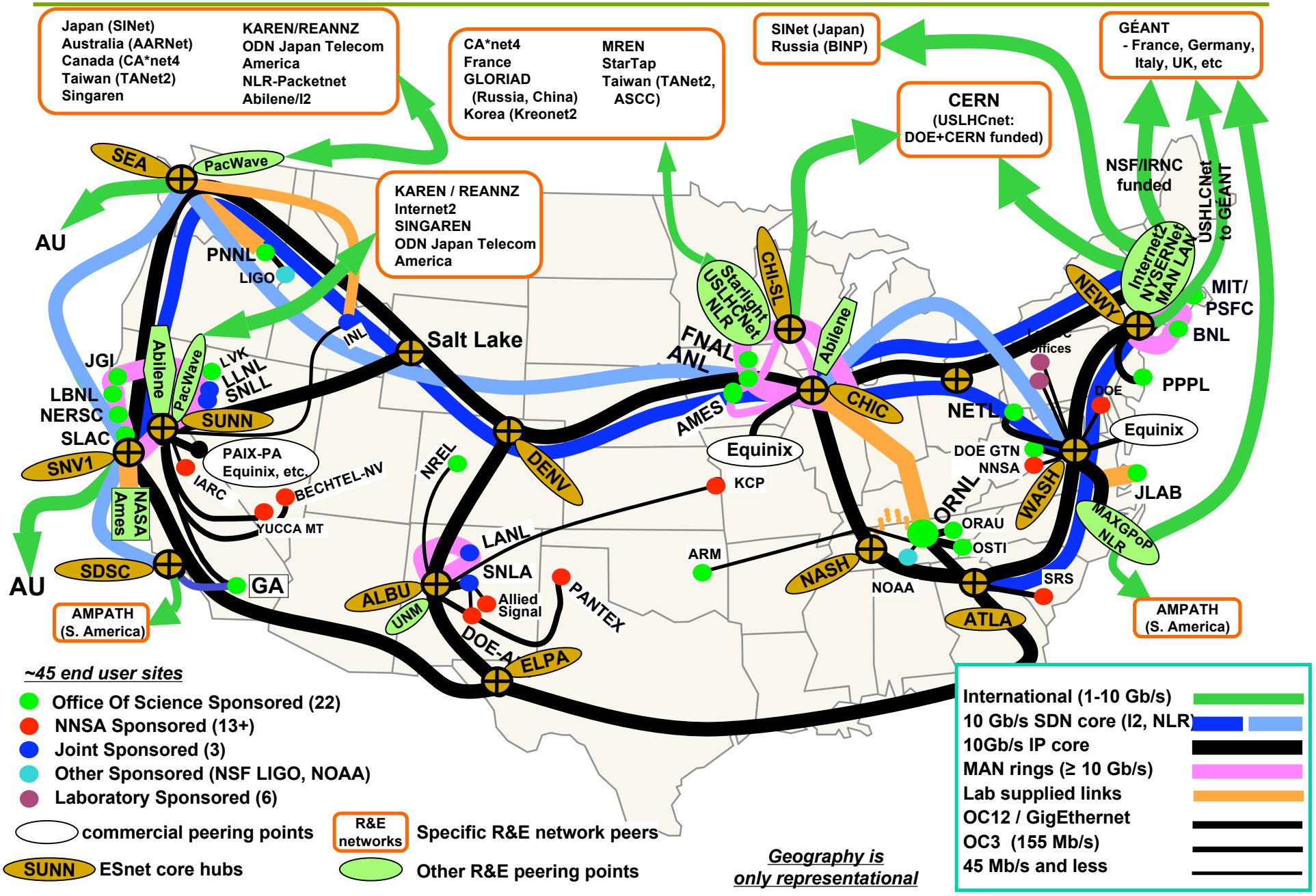
* USLHCnet plays a role in some of the trans-atlantic links

LHCOPN

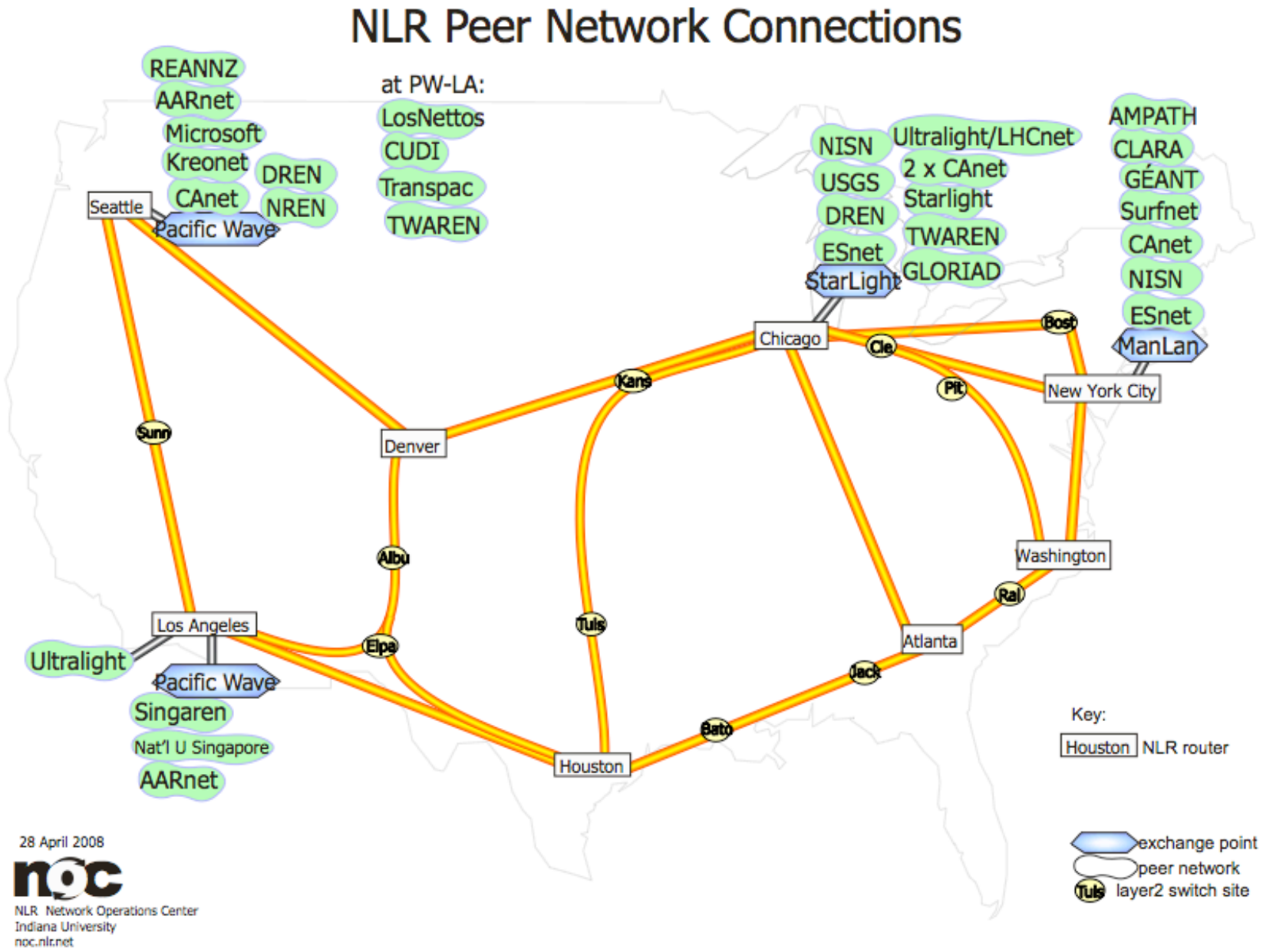
LHCOPN – current status



ESnet Provides Global High-Speed Internet Connectivity for DOE Facilities and Collaborators (12/2007)



NLR


NLR Peer Network Connections
REANNZ
AARnet
Microsoft
Kreonet
CAnet
DREN
NREN
Pacific Wave
Seattle
at PW-LA:
LosNettos
CUDI
Transpac
TWAREN
NISN
USGS
DREN
ESnet
StarLight
Ultralight/LHCnet
2 x CAnet
Starlight
TWAREN
GLORIAD
AMPATH
CLARA
GÉANT
Surfnet
CAnet
NISN
ESnet
ManLan
Chicago
Cle
Bost
Pit
New York City
Kans
Sunn
Denver
Albu
Washington
Ral
Los Angeles
Ultralight
Pacific Wave
Singaren
Nat'l U Singapore
AARnet
Elpa
Tuls
Atlanta
Jack
Hous
Houston
Key:
Houston NLR router
exchange point
peer network
Tuls layer2 switch site
28 April 2008
noc
NLR Network Operations Center
Indiana University
noc.nlr.net

Internet2 Network

ciena | INDIANA UNIVERSITY | infinera | Juniper NETWORKS | Level(3) COMMUNICATIONS

CONNECTORS

3ROX
CENIC
CIC OmniPoP
Drexel University
GPN
Indiana GigaPoP
KyRON
LEARN
LONI
MAGPI
MAX
MCNC
Merit Network
MREN
NOX
NYSERNet
Oregon Gigapop
Pacific Northwest GigaPoP
SoX
University of Memphis
University of New Mexico
University of South Florida
University of Utah/UEN

INTERNET2 NETWORK INTERNATIONAL REACH

AMERICAS
Argentina (RETINA)
Brazil (RNP2/ANSP)
Canada (CA*net)
Chile (REUNA)
Colombia (RENATA)
Costa Rica (CR2Net)
Ecuador (CEDIA)
El Salvador (RAICES)
Guatemala (RAGIE)
Mexico (Red-CUDI)
Panama (RedCyT)
Peru (RAAP)
Uruguay (RAU2)
Venezuela (REACCIUN2)

EUROPE and MIDDLE EAST
Albania (ASA/INIMA)
Austria (ACOnet)
Belgium (BELNET)
Bosnia-Herzegovina (BIHARNET)
Bulgaria (ISTF)
Croatia (CARNet)
Cyprus (CYNET)
Czech Republic (CESNET)
Denmark (Forskningsnettet)
Estonia (EENet)
Finland (Funet)
France (Renater)
Germany (G-WIN)

EUROPE and MIDDLE EAST cont'd
Greece (GRNET)
Hungary (HUNGARNET)
Iceland (RHnet)
Ireland (HEAnet)
Israel (IUCC)
Italy (GARR)
Jordan (JUNET)
Latvia (LATNET)
Lithuania (LITNET)
Luxembourg (RESTENA)
Macedonia (MARNET)
Malta (Univ. Malta)
Netherlands (SURFnet)
Norway (UNINETT)
Palestinian Territories (Gov't Computing Center)
Poland (PIONIER)
Portugal (RCTS2)
Qatar (Qatar FN)
Romania (RoEduNet)
Serbia-Montenegro (AMREJ, UoM/MREN)
Slovakia (SANET)
Slovenia (ARNES)
Spain (redIRIS)
Sweden (SUNET)
Switzerland (SWITCH)
Syria (HIAST)
Ukraine (URAN)
United Kingdom (JANET)
Turkey (ULAKBYM)

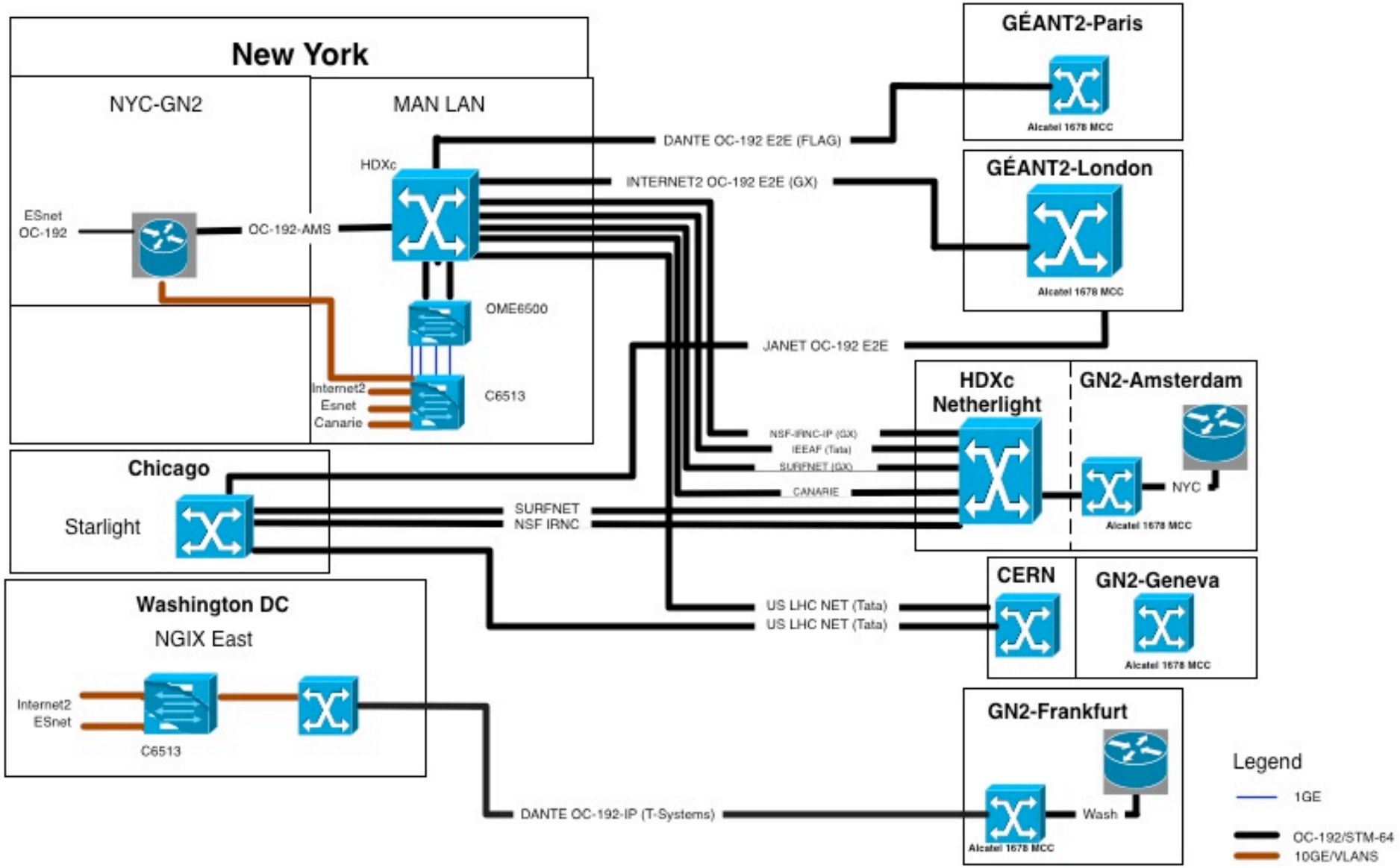
ASIA and PACIFIC
Australia (AARNET)
China (CERNET,CSTNET,NSFCNET)
Fiji (USP-SUVA)
Hong Kong (HARNET)
India (ERNET)
Indonesia (ITB)
Japan (SINET, WIDE, JGN2)
Korea (KOREN, KREONET2)
Malaysia (MYREN)
New Zealand (KAREN)
Philippines (PREGINET)
Russia (RBnet, RUNNET)
Singapore (SingAREN)
Taiwan (TANet2, ASNet)
Thailand (UNINET, ThaiSARN)
Vietnam (VINAREN)

MULTINATIONAL NETWORKS
APAN
GEANT2
redCLARA

AFRICA
Algeria (CERIST)
Egypt (EUN/ENSTINET)
Morocco (CNRST)
South Africa (TENET)
Tunisia (RFR)

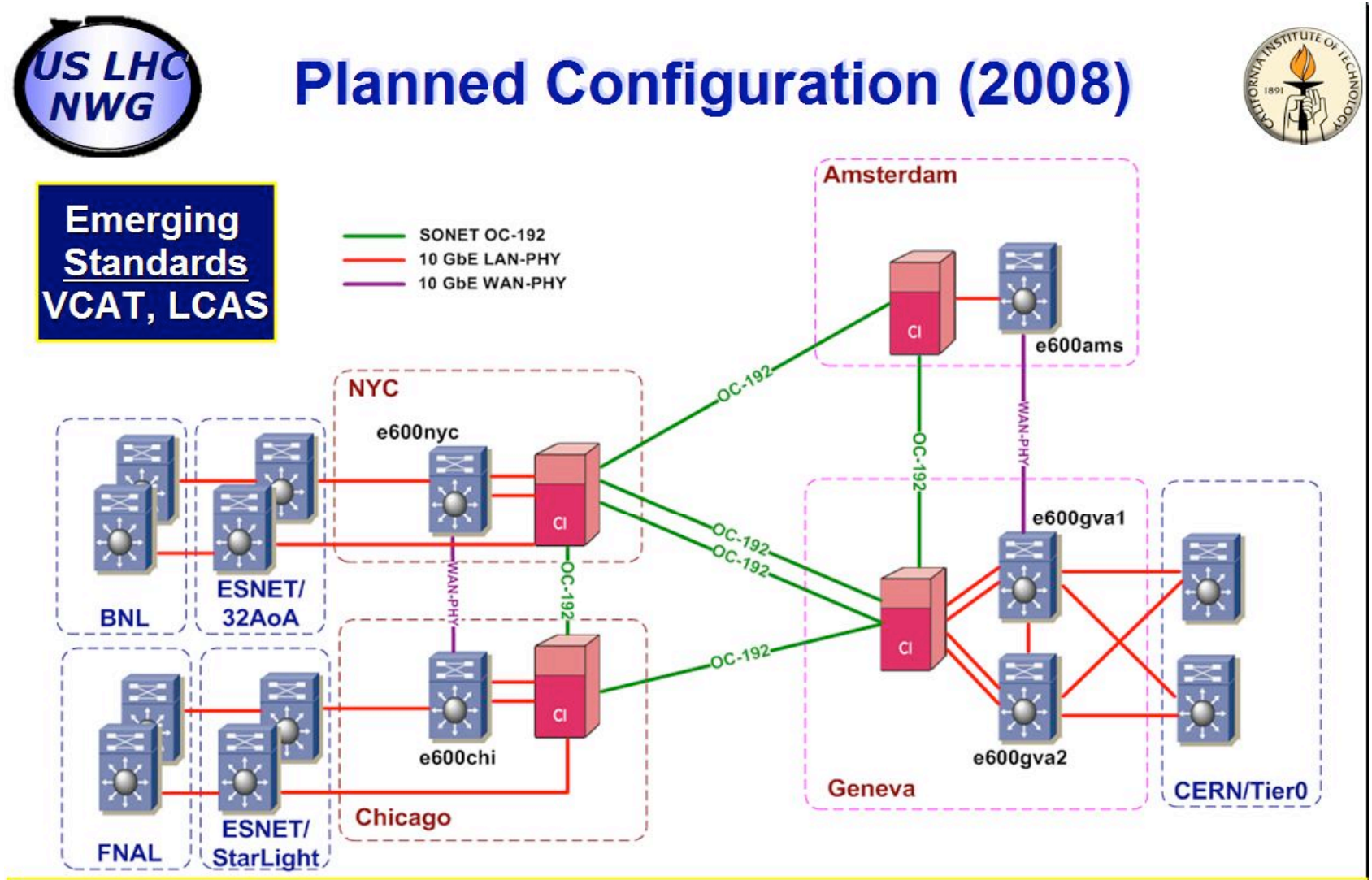
CENTRAL ASIA
Armenia (ARENA)
Georgia (GRENA)
Kazakhstan (KAZRENA)
Tajikistan (TARENA)
Uzbekistan (UZSCI)

Current Trans Atlantic R&E Capacity

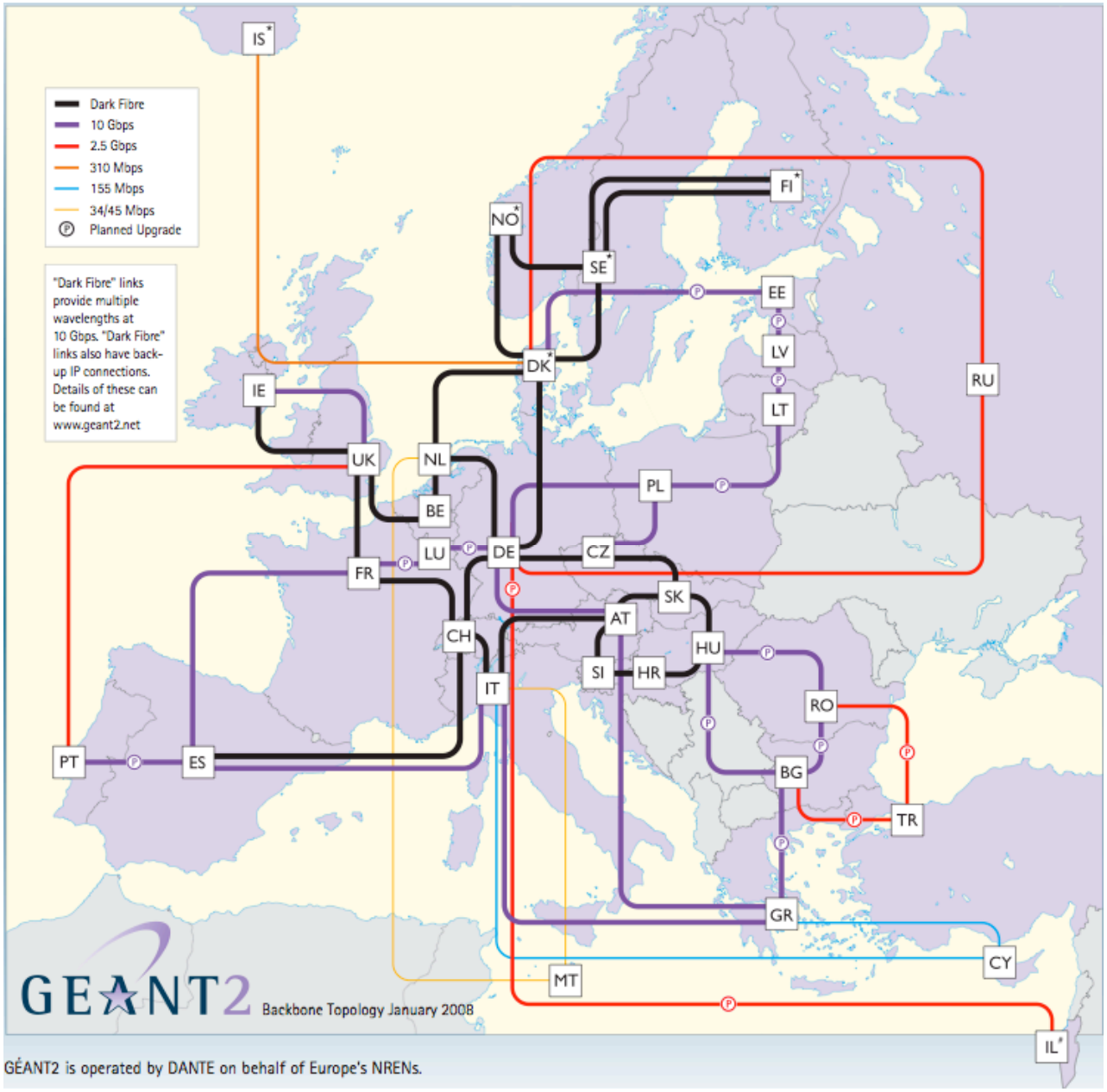


Drawing from Heather Boyles @ Internet2 May 9 2008

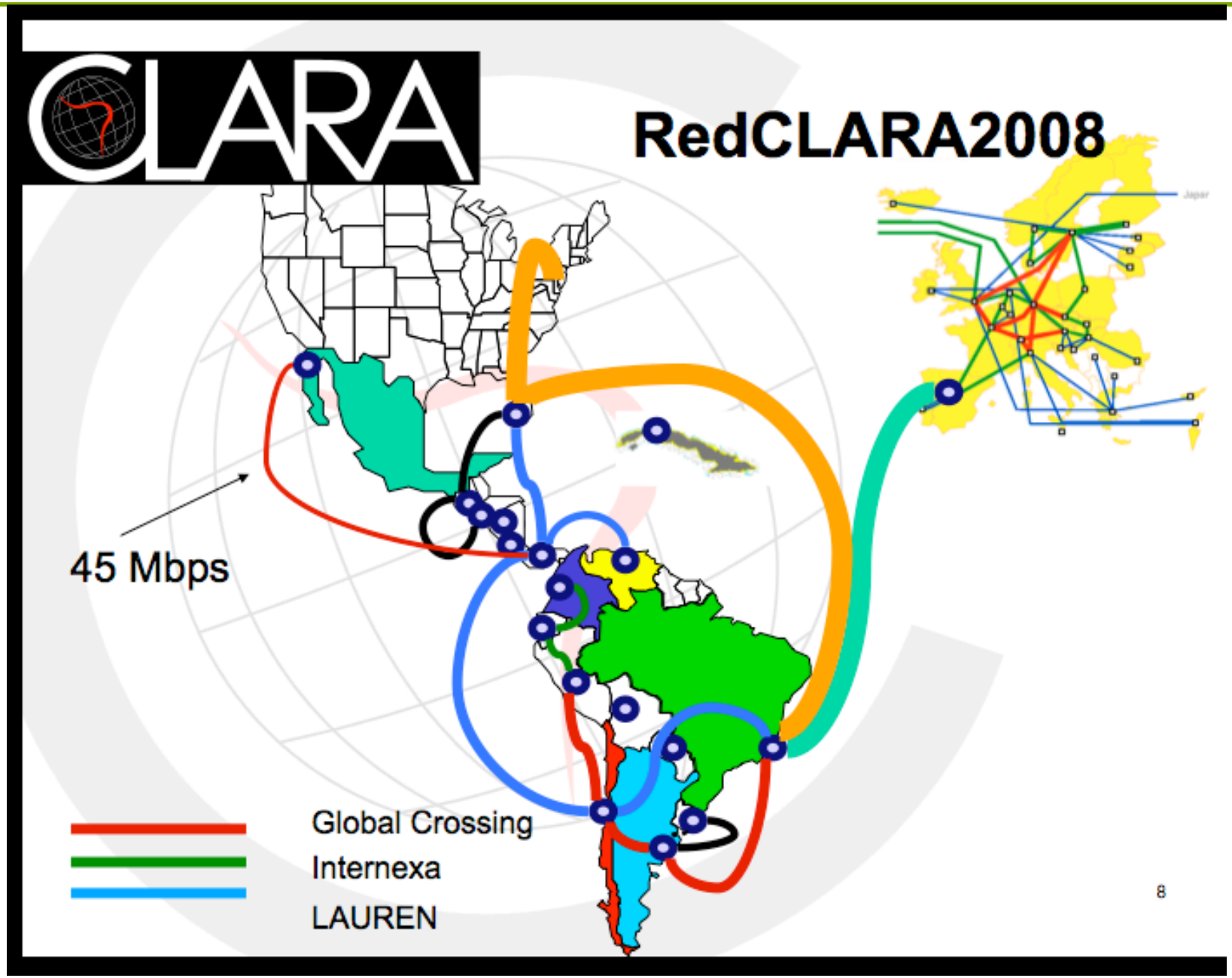
USLHCnet


US LHC NWG
Planned Configuration (2008)
Emerging Standards VCAT, LCAS
SONET OC-192
10 GbE LAN-PHY
10 GbE WAN-PHY
Amsterdam
e600ams
NYC
e600nyc
BNL
ESNET/ 32AoA
FNAL
ESNET/ StarLight
e600chi
Chicago
Geneva
e600gva1
e600gva2
CERN/Tier0
OC-192
WAN-PHY
Robust fallback at layer 1 + next-generation hybrid optical network:
Dynamic circuit-oriented network services with BW guarantees

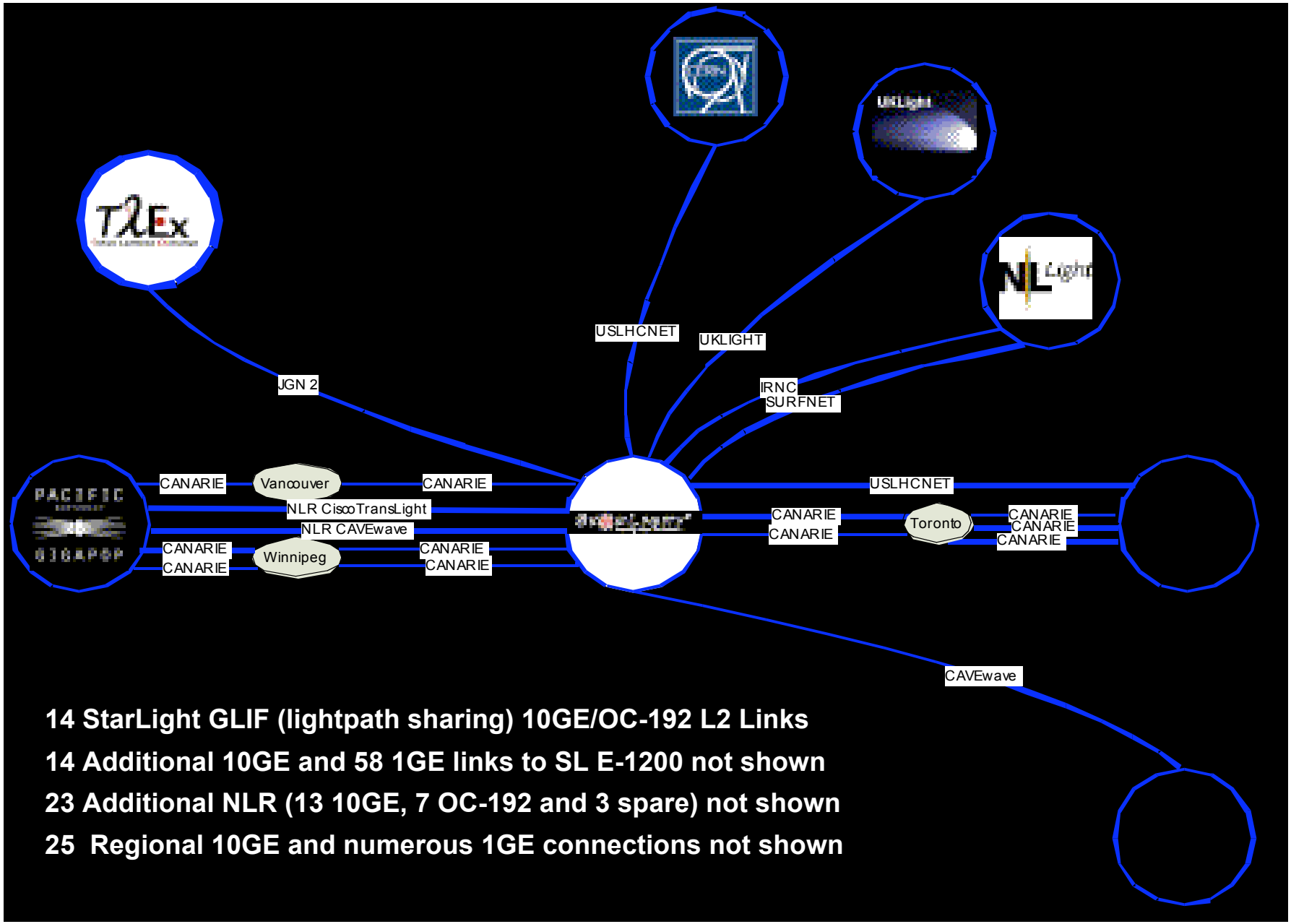
GEANT2


Dark Fibre
10 Gbps
2.5 Gbps
310 Mbps
155 Mbps
34/45 Mbps
Planned Upgrade
"Dark Fibre" links provide multiple wavelengths at 10 Gbps. "Dark Fibre" links also have back-up IP connections. Details of these can be found at www.geant2.net
IS
NO
SE
FI
EE
LV
LT
RU
DK
IE
UK
NL
PL
BE
LU
DE
CZ
FR
SK
AT
CH
HU
SI
HR
IT
RO
PT
ES
BG
TR
GR
CY
MT
IL
GEANT2
Backbone Topology January 2008
GÉANT2 is operated by DANTE on behalf of Europe's NRENs.

REDClara


CLARA
RedCLARA2008
45 Mbps
Global Crossing
Internexa
LAUREN
8

Starlight


USLHCNET
UKLIGHT
JGN 2
IRNC
SURFNET
CANARIE
Vancouver
CANARIE
NLR CiscoTransLight
NLR CAVEwave
CANARIE
CANARIE
Winnipeg
CANARIE
CANARIE
USLHCNET
CANARIE
CANARIE
Toronto
CANARIE
CANARIE
CANARIE
CAVEwave
14 StarLight GLIF (lightpath sharing) 10GE/OC-192 L2 Links
14 Additional 10GE and 58 1GE links to SL E-1200 not shown
23 Additional NLR (13 10GE, 7 OC-192 and 3 spare) not shown
25 Regional 10GE and numerous 1GE connections not shown

Gloriad

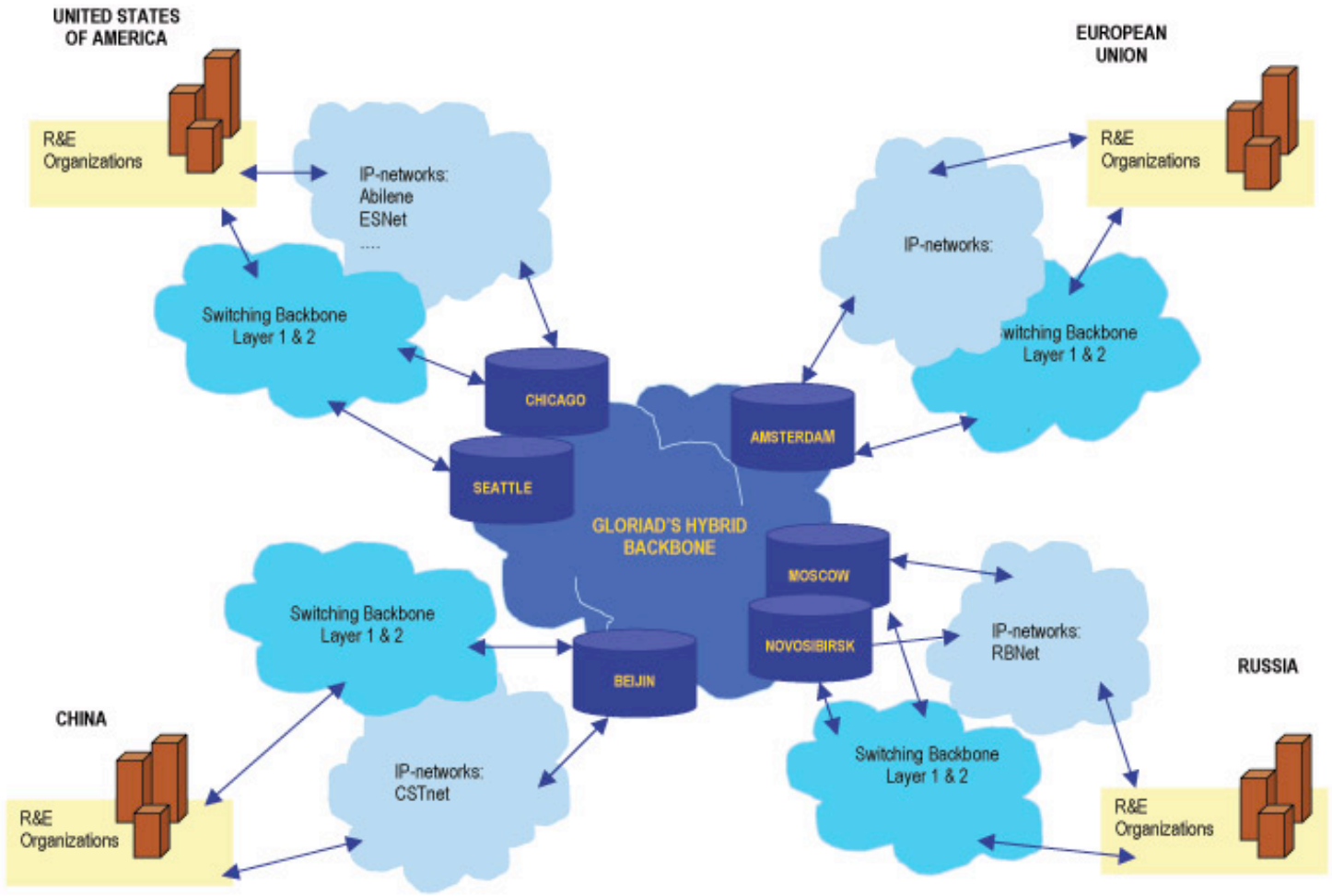


Fig. 1. The overall GLORIAD's Hybrid B ackbone Topology

Discussion Points

- How much international traffic will your center really source and sink?
  - Do you know?
  - Have you told your network provider?
- Does your network provider believe your estimates?
  - Network providers have been hearing: the Physicists are coming, the Physicists are coming, for years…
- Is your traffic going to show up as a gradual ramp, or a step function?
  - Network engineers typically start looking at capacity issues when the links reach 50% utilization, and users typically don't start experiencing problems until utilization exceeds 70-80%. Is this going to happen overnight, say in late August when students are coming back to campus?
- Geography matters
  - Capacity across the Atlantic is in good shape.
  - Capacity across the Pacific is challenging.
  - Capacity to and within South America is pretty bad, but EU is spending money to improve it.

Conclusions

- Most of the networks involved collaborate closely and have processes in place to ensure that we can meet the requirements.
  - Assuming we understand and believe the requirements with sufficient lead time!